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Contents

The Value of Collaboration

WHEN the new president of the British Wood Preserving Association, Mr. W. E. Vesey, made a point of warning delegates to the annual convention in Cambridge last month of the danger of unco-ordinated research by various national and world groups in the field of preservation techniques, he touched on an aspect that is certainly going to demand increasing attention in the future.

Because the annual convention is the highlight of the organisation's year, it arouses great interest and comment which much of the day-to-day work of the BWPA deserves but necessarily fails to do. For example, there are several aspects of its work which will now take on growing significance; one is its participation on the various FAO committees concerned with problems of wood preservation at their meetings held either in Britain or other member countries. Another important line of work pursued by the association is the maintenance of friendly and technically-productive contact with overseas bodies concerned with establishing standards for wood preservatives and of methods for testing these materials and techniques.

Now that Britain has formally applied for membership of the European Common Market, these and similar activities of the BWPA may be expected to assume a fresh importance. The eventual effect of this move on the production of materials for wood preservation—or indeed on certain features of the pest control industry as a whole—has yet to be fully assessed, but there is no doubt that the industry's policy in the past of fostering close links with its colleagues in other parts of the world will now be particularly valuable.

Despite the encouraging international flavour of the BWPA convention this year (with delegates or speakers from Australia, France, Germany, Yugoslavia, Sweden, the USA, Canada, Ceylon, East Africa, Finland, Malaya and Norway) it was very noticeably not bounded by the limits of Europe. Whatever the development of the Common Market talks, such mutual collaboration as this at least to a certain stage will always manage to transcend most frontiers. Whether scientific knowledge is always exchanged with the most altruistic of motives is of rather less importance than that the co-operation exists at all, and to the fullest possible extent.

DEVELOPMENT AND APPLICATION OF SOIL PESTICIDES

by F. CALL*, Ph.D.

The author here reviews the long history of soil pesticide materials, discusses current trends of research and practical application, and suggests the direction this aspect of pest control is likely to follow in the immediate future.

SOIL pesticides have been in large scale use since the successful demonstration of the effectiveness of carbon disulphide for the control of phylloxera on vines in France almost one hundred years ago. In the last quarter of the nineteenth century over 100,000 acres of soil were fumigated annually in Europe. Since that time many substances have been tested as fumigants; thus Gough (1945)[1] in reviewing the literature on soil insecticides, lists over 600 references to trials with almost 250 compounds. Such has been the speed of progress since 1940 that of these compounds only two still find appreciable use today.

The desirable properties of a soil pesticide have been defined by Gough (1945) as toxic to the pest but non-toxic to plants and having no permanent effect on the soil, economic and easy to apply with good powers of dispersion through the soil, yet readily dissipated or removed after the treatment is complete. No soil pesticide as yet fulfils all the requirements, but improvement is steady. Complete sterilisation is not generally required in agricultural soils and the trend is towards a greater selectivity of action in pesticides. Thus a thorough treatment of soil pesticides would include herbicides, fungicides, insecticides, nematicides and bactericides. The present work is confined largely to soil insecticides and nematicides except where a compound shows promise of control of other pests.

Part of the difficulty of controlling soil pests arises from the nature and magnitude of the problem. Attempts are normally made to control pests occurring in the cultivated layer of top soil, and treatment to a depth of twelve to fifteen inches is usually considered satisfactory. Special cases do arise; thus Baines, Foote, Stolzy, Small and Garber (1959)[2] found that the citrus nematode (*Tylenchulus semipenetrans* Cobb) occurred at a depth of 6 to 8 ft. in California and were only able to obtain adequate control at this depth by greatly increasing the dose of nematicide. Treatment of the soil to the normal depth of 15 ins. involves the treatment of about 1,500 cu. yds. or more than 1,200 tons of soil per acre of surface. In addition, the surface of the soil is open to the air and exposed to rain and wind, so that volatile fumigants will readily escape or be washed into the deeper layer. Since several hundred acres may require treatment it is scarcely practicable to cover the surface with some form of impervious cover, though this may be done for small nursery beds. The pests to be controlled are scattered throughout this soil mass in perhaps various stages of development from eggs to adults, each stage probably having a different susceptibility to the toxic chemical.

High mortality rate

Many soil pests have a very high rate of population increase during the growing season and nothing less than a 99% mortality may be acceptable as effective control. Insecticides and nematicides appear to have a similar history of development although progress has been most rapid in insect control. In both cases the earliest agents to be used were fumigants, usually liquids of fairly high vapour pressure. As experience and knowledge accumulated, fumigants of still higher boiling point and lower vapour pressure were found to be superior. Such fumigants have usually been applied by injecting small volumes of the liquid into the soil, but recently it has

**Imperial College of Science and Technology, London.*

been found advantageous to apply the fumigant adsorbed on to granules. The use of fumigants may be superseded by persistent solid pesticides which kill by contact action and which may be applied to the soil in solution or in admixture with fertilisers.

Prior to 1945 the search for an efficient soil insecticide tended to concentrate on liquids of high volatility such as carbon disulphide, dichlordiethyl ether, chloropicrin and calcium cyanide (which yields hydrogen cyanide in moist soils). Good control was obtained in many cases although the dose rates were very high and often uneconomic (e.g. of the order of 1,500 lbs. per acre in the case of carbon disulphide). These volatile fumigants have now been almost completely superseded by the solid contact insecticides aldrin, dieldrin, chlordane and heptachlor which have resulted in excellent control of many soil insects at rates of application as low as 0.5 to 10 lbs. per acre. The problem thus becomes one of securing an adequately even distribution of the pesticide.

Methods of application

These insecticides may be applied as emulsions, wettable powders, dusts or absorbed on granules. It has been observed that emulsions may be adversely affected by passage through soil, frequently breaking and depositing the pesticide in the upper layers. In many respects granule formulation may be easier and cleaner to use. Granulated vermiculite is a very satisfactory carrier for aldrin or heptachlor. The insecticide may vary between 2% and 40% by weight of the formulation, giving satisfactory control of wireworms at dosage rate of 1.25—2.5 lbs. per acre.

Aldrin and dieldrin may be very persistent in soils. Thus, good control of the potato tuber flea beetle was obtained for eight years after a single application of 10 lbs. per acre, while at lower rates of 2—5 lbs. per acre, control persisted for at least four years. Against the cabbage maggot, *Hyeleme brassicae*, however, the effectiveness of aldrin applied at the higher rate of 10 lbs. per acre decreased after two years. It has been possible to recover 15% of the chlordane and 8% of the lindane originally applied to turf as a top dressing twelve years previously. On the other hand, considerable losses of aldrin, endrin and Shell SD 4402, of the order of 50—60%, have been observed within twenty-four hours after surface application to soils at a relatively high surface temperature. DDT appeared to be much less affected by temperature. It seems to be distinctly advantageous to cultivate the soil after application so as to mix the insecticide with the surface layer of soil and such cultivation has been shown to increase the persistence of aldrin[3]. A complicating factor is the conversion of aldrin to dieldrin in soils probably through the action of micro-organisms. Equal amounts of aldrin and dieldrin have been recovered from aldrin-treated soil after sixteen months under field conditions and after only 3.3 months at 37°C. There was little conversion of aldrin in autoclaved soils containing few micro-organisms. Lindane is broken down even more rapidly to non-toxic products. Within two weeks the lindane demonstrable by a bioessay method has decreased to 66% of that shown by chemical methods[4]. Under some conditions subsequent changes may be much slower; thus Lichtenstein and Polivka[3] detected by bioessay 8% and by chemical means 41% of the lindane applied eleven years earlier as a top dressing to turf. A similar discrepancy between bioassay and chemical determinations has been observed with aldrin, dieldrin and heptachlor. Considerable amounts of lindane have been found to be translocated into red clover and such a mechanism may be responsible for some of the losses observed. Persistence also appears to depend on the soil type, increasing with the percentage of organic matter. Thus insecticides tend to persist longer in peat soils than in sand or silts, and the persistence of heptachlor is in the decreasing order, peat, silty clay loam, silt loam.

Peat soils appear to stabilise aldrin which undergoes a much smaller degree of conversion to dieldrin. This stabilising effect varies with the insecticide. Thus after three and a half years a peat soil contained 1.4 times as much DDT, 4.25 times as much aldrin and 8.48 times as much lindane as a silt soil under similar conditions[4]. Peat soils have been demonstrated to adsorb or bind more phorate than either clays or sands and this adsorption appears to protect the insecticide against oxidation. Persistence is greater at lower temperatures and in dry conditions. Downward leaching of DDT, aldrin and lindane have been demonstrated, such leaching being greater in peat than in silt soils[5]. Parathion was found to move both horizontally and vertically under non-leaching conditions suggesting that diffusion was occurring.

Control of nematodes

The control of plant parasitic nematodes in soil has not arrived at the same stage as that of soil insects although progress is rapid and seems to be along similar lines. The most widely used economically successful treatment involves the use of volatile soil fumigants and many thousands of acres are treated each year in the United States. In Great Britain soil fumigation is sparingly practised and the control measure usually recommended is based on crop rotation. Soil fumigation has certainly not been very successful in Britain except on certain light soils and this lack of success is most likely due to the lower soil temperatures which would tend to retard the movement of a fumigant vapour through a soil and also to the frequency of rain which will tend to wash the fumigant deeper into the soil as well as retarding movement by the reduction of the air

porosity, which is the most important single factor controlling movement of the fumigant vapour inside the soil. If new nematicides not dependent on fumigant action become available the position in Britain may well change rapidly.

Carbon disulphide is certainly the oldest and also the most widely used fumigant prior to 1945. Root knot nematodes are controlled by rates of 1000—3000 lbs. per acre, but this high dose rate as well as the inflammability and explosive hazard have made it obsolete. Chloropicrin was introduced as a soil fumigant after 1918 when peaceful uses were sought for the large stocks of material remaining after the first World War. Its outstanding fungicidal and herbicidal properties in addition to its valuable insecticidal and nematicidal effects made it a popular general soil sterilising agent and large acreages are still treated with it in the U.S.A. in spite of its unpleasant lachrymatory properties. Because of the high vapour pressure the surface of the soil must be sealed, by glue-coated paper, plastic sheets or by simply spraying water on the surface. Chloropicrin is too expensive for wide-spread fumigation against nematodes, but attempts have been made to reduce the cost by adding diluents such as ethylene dichloride, while the Dow Chemical Co. has recently announced the introduction of Trizone, a mixture of methyl bromide, chloropicrin and propargyl bromide, which is claimed to have a broad spectrum of action. Another successful method of reducing the high cost of treatment is to confine this to badly infested spots, and such partial treatments may be sound economics. As might be expected from its herbicidal properties chloropicrin is very phytotoxic and adequate time must be allowed for dispersion after treatment (5—20 days depending on soil temperatures).

Methyl bromide

The value of methyl bromide for soil fumigation was pointed out as long ago as 1935 by Richardson and Johnson[6]. Since it is a gas at normal temperatures, the soil must be covered by an impermeable cover, nowadays usually of plastic, which must be sealed to the ground round the edges to form a gas-tight chamber above the surface of the soil. This makes the treatment of very large areas impracticable and methyl bromide finds greatest use for the treatment of seed beds, nursery beds or glasshouses. Methyl bromide has a large vapour pressure and thus penetrates rapidly into all crevices. Similarly the gas disperses rapidly after the fumigation and planting can often take place 4—5 days after treatment.

Coupled with this property is that of low phytotoxicity to many plants, and the fumigant has been widely used in plant quarantine treatment. Certain plants such as chrysanthemums, carnations, violas and salvia are more susceptible and may be retarded for some weeks by treatment. Nematodes appear to be very sensitive to methyl bromide and require a very small dose; fungi require a larger dose, while still higher doses are required large acreages under plastic tarpaulins at a dose rate of four pounds of methyl bromide per 100 cu. ft. of space above the soil.

A great impetus was given to the practice of soil fumigation in the U.S.A. by the discovery of the nematicidal properties of DD by Carter[7] in 1943. This material is a by-product of the plastics industry and consists of a mixture containing 50—75% of 1.3 dichloropropene with 1.2 dichloropropane and other higher chlorinated propanes. The active nematicidal agent is the 1.3 dicloropropene and this is now available in a substantially pure form in America under the name of Telone which has been shown to be more effective than DD against certain nematodes in laboratory tests. There is some evidence, however, that the higher fractions may exert a not inconsiderable nematicidal effect. DD gives effective control of sugar beet nematode, *Heterodera schachtii*, and of the root knot nematode, at dosage rates of 200—600 lbs. per acre. Excellent control is obtained against wireworms, and although DD is not generally regarded as an efficient fungicide, it has given effective control of many fungal diseases such as the *Fusarium* pea seedling rot and *Sclerotium rolfsii* on tobacco and on sweet potato. Trials in Great Britain against potato root eelworm, *Heterodera Rostochiensis* have however proved disappointing. Thus Peters and Fenwick[8] obtained only a 50% reduction in nematode population even at dose rates as high as 800 lbs. per acre while rates of 450 lbs per acre were unsuccessful in Jersey. In Western Scotland, the use of DD has been shown to be economic for early potatoes. In the U.S.A. DD gives better results in heavier soils, while treatment in July or October gives better control of root knot nematode than treatment in March, when the soil temperatures are lower. There is no evidence of build-up of phytotoxic residues in soils after five successive annual fumigations with 400 lbs. per acre.

Ethylene dibromide

Shortly after the introduction of DD the saturated aliphatic compound ethylene dibromide was found to be a very potent nematicide, being in fact more toxic to nematodes than DD on a weight basis, so that the cost of treatment is comparable to that with DD. Ethylene dibromide has a high boiling point and like DD requires no sealing of the surface for effective fumigation. The new fumigant rapidly became popular and many thousands of acres are treated every year in the United States. The rate of application is of the order of 4—6 gallons per acre and the diluents are often added to increase the bulk, formulations containing between 10 and 85% of ethylene dibromide being commercially available. All tests show that ethylene dibromide is a poor fungicide, yet many instances have been published

of its use to control fungus-induced diseases. It is believed that this may be due to the control of nematodes or wireworms, which may facilitate the entry of fungus into the plant.

Research into toxic action

The success of DD and ethylene dibromide as soil fumigants stimulated the search for still more powerful nematicides of the halogenated hydrocarbon type, and a very great number of compounds have been tested. Moje[9] has reviewed the factors affecting toxicity to nematodes and concludes that the toxic action is due to a combination of the toxic agent with nucleophilic centres in the nematode leading to inhibition of vital biological processes. He was able to show that in general the toxicities of a series of compounds is closely correlated with the S_N2 reaction rate. The nematicide must also have adequate stability in moist soils and Moje suggested that the best nematicide would have a high rate of reaction in the bimolecular S_N2 reaction and a low rate in S_N1 reactions. Many halogenated olefines and acetylenes have been patented as nematicides, but there is up to now insufficient evidence to assess their merits. One compound which seems likely to be used on a large scale alone or in combination with other agents is propargyl bromide. This is stated to be twice as effective as DD on a weight basis against the citrus nematode. It is, of course, a constituent of the new Dow formulation Trizone.

Chlorobromopropene, which is prepared from DD, has been tested as a nematicide, and is stated[10] to be more toxic to the root knot nematode than DD or ethylene dibromide. Trials in soil, however, have been disappointing, probably because of the compound's inherent instability. It is also an effective fungicide.

Control with Nemagon

The most outstanding nematicide developed to date appears to be Nemagon, 1,2. dibromo 3, chloropropane, which is stated to be 2—5 times as toxic as ethylene dibromide and 8—10 times DD. Although the larvae of *Meloidogyne incognita* remain alive in treated soil for some months after treatment, they appear to have lost the power of invading and infecting plants. Effective control of root knot has been obtained with doses of Nemagon as low as 5—8 gallons per acre injected at 12 inches depth. The high boiling point of Nemagon and consequently the low vapour pressure at normal soil temperatures results in much greater persistence in the soil. Nemagon absorbed on granules and placed in soil at 4 ins. depth gave good control of root knot in the surface layers usually difficult to treat and at all depths down to 24 ins.[11]. An outstanding feature of Nemagon is the low phytotoxicity and many plants are not harmed at doses twenty times the effective nematicidal doses. The fumigant can in fact be applied when certain crops are growing. Nemagon absorbed on granules may be applied mixed with fertiorliser at the time of sowing seed transplanting. Good control of root knot has been obtained in this way[12].

Alongside this series of halogenated hydrocarbon fumigants there has recently come into use another series of compounds whose toxic principle is the fumigant, methyl isothiocyanate. The toxicity of the isothiocyanates to nematodes has long been known and phenyl isothiocyanate adsorbed on talc dust was shown to give effective control of the potato root eelworm at economic dosage rates as long as ago 1937[13]. This treatment does not seem to have been used to any degree on a large scale. More recently three chemicals have been introduced which are themselves solids, but which break down inside the soil to yield among other products methyl isothiocyanate. The most popular of these is sodium N-methyl dithiocarbamate, known as Vapam in the United States and metham sodium in Great Britain. This is a deliquescent solid which is thus always used in aqueous solution and is applied to the surface of the soil as a concentrate, being subsequently watered in, or else is added to the irrigation water. Vapam appears to be relatively ineffective when applied by the chisel or plough method, but it is particularly useful where an overhead irrigation system exists[14]. Good control of root knot is obtained at rates of application as low as ½-lb. per 100 sq. ft. of surface, while the citrus nematode has been controlled to depths of 4—6 ft. Vapam is claimed by its manufacturers to have a balanced, all-round action rather than to be outstanding in any one field, and is a herbicide, fungicide as well as a nematicide. Good weed control can be obtained, but some crop plants may be retarded. Two other solid agents which also act in a similar manner to Vapam, decomposing in moist soil to yield methyl isothiocyanate are Mylone, 3, 5-dimethyl-tetrahydro-1, 3, 5, 2H-thiazdiazine-2-thione, which is an efficient nematicide, but rather phytotoxic[15], and Tridipam, N.N.-dimethylthiuram disulphide[16]. Tridipam appears to be a balanced, all-round agent like Vapam, but large scale experience with it is lacking as yet. The latest member of this series about which there is little information as yet is Trapex, which is believed to be pure methyl isothiocyanate. It is interesting that ethyl dimethyl dithiocarbamate has been used in Russia to control the potato root eelworm. Although this compound is stated to be non-phytotoxic, the rates of application appear high and the treatment may be too costly[17].

Potato root eelworm

Good control of the potato root eelworm in Scotland has been obtained by applying simple mercury compounds, such as the oxide at rates of application as low as 2½ to 5 lb. per acre. There is some reason to believe that these compounds are rapidly broken down in soil to free mercury which exerts a fumigant action. Since the range

of this action is, however, extremely small, the problem is essentially one of securing adequate distribution of the compounds. Considerable progress appears to have been made towards a solution of this problem[18].

Much attention has been devoted to the development of contact nematicides, particularly those which can be distributed by irrigation or rain. Many simple cyclic compounds such as para and meta cresols and xylenols which normally have negligible nematicidal properties have been shown to become highly effective when solubilised by means of an emulsifying agent and applied to the surface of the soil[19]. The disadvantage of this method is the large amount of water required to distribute the agent in depth in the soil. Very good control is obtained in the surface layers of the soil which are normally difficult to treat satisfactorily by orthodox soil fumigants. The method is interesting as the first instance of the use of a deliberate formulation based on the combined action of a toxic chemical and a spreading agent.

Good control with parathion

The only one of the organo-phosphorus insecticides which appears to have any nematicidal action is parathion. This has given good control of chrysanthemum eelworm and of meadow nematode in boxwood when sprayed on to plants as an emulsion or wettable powder. The first specific soil nematicide to be developed in this class is VC13, 0,2,4,-dichlorophenyl-0, 0-diethyl phosphorothioate. This is a non-volatile liquid which appears to have no herbicidal, insecticidal or fungicidal properties. It is usually used as an emulsifiable concentrate diluted with water and applied to the soil surface at the rate of 12-50 gallons of concentrate per acre. Being comparatively non-toxic to plants it may be applied to soil bearing living plants and is particularly useful for turf. One application is stated to last several months. VC13 is particularly effective against free-living nematodes and those that emerge from infected roots[15]. More recently another organo-phosphate is stated to be undergoing tests as a nematicide and promises to be useful. This is American Cyanamide 18133, which is stated to have the formula 0,0-diethyl-0,2-pyrazinyl-phosphorothioate[20].

Three other solid nematicides which kill by contact action are PRD, cis, 3, 4-dichlorotetrahydro thiophene-1, 1-dioxide, its trans isomer ORD and the monochloro derivative FRD. ORD is the least toxic of the three while FRD is slightly more difficult to manufacture so that PRD is the compound most likely to be adopted and which has undergone most trials. PRD is a powerful nematicide which kills nematodes rather slowly and which persists in soil for long periods. It is toxic to seeds and seedlings but not to established plants at nematicidal doses. When applied to the soil surface in late summer or early fall it is evenly distributed throughout the soil to a depth of twenty inches by fall rains and winter snows[21]. In greenhouse tests PRD compared favourably with Nemagon and was somewhat better than VC13 as regards control of a number of species of nematodes. Interest in thiophene derivatives is stimulated by the identification by Uhlenbroek and Bijloo[22], of the nematicidal principles of the African marigold, Tagetes, as bithienyl and terthienyl derivatives. These workers (1960) have now synthesised a number of polythienyl compounds and found many powerful new nematicides. Field trials have not as yet been reported.

Another interesting line of work which may eventually result in the development of powerful systemic nematicides arises from the demonstration that compounds such as maleic hydrazide and sodium fluoracetate after foliar application may be translocated to the roots of a plant and reduce the incidence of attack by nematodes on these roots,

The problem of nematode control by chemical means is being attacked on a number of independent lines and it is very probably that, should the newer agents prove successful in practice, chemical nematicides may be adopted much more widely in Great Britain than they have in the past. The hopes of an all-round nematicide capable of controlling a wide variety of species is being abandoned and there is an increasing tendency for particular problems to be treated by particular pesticides.

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The choice of equipment for applying non-selective herbicides is determined largely by the kind of herbicide used and by the site conditions. This article discusses some of these factors, and considers the relative merits of spray applied and granular materials.

METHODS OF USING NON-SELECTIVE HERBICIDES

By D. MONTGOMERY *

UNTIL quite recently herbicides used to control growth on industrial sites, on verges or in ditches were applied in much the same way as selective herbicides on cropland but in the last few years ther have been some interesting developments in the use of granules for total weed control and in specially designed equipment for the application of sprays and granules.

With one or two exceptions all the chemicals or formulations used for weed control need a carrier; this is a matter of applying a small amount of chemical uniformly

Controlling growth near factory premises by a non-selective herbicide, applied dry with a hand spreader.

over a large area. The exceptions are sodium chlorate, perhaps, though fire risk would generally preclude its use and sodium borates used at high rates for preventing weed growth on clear ground or under tarmac surfaces.

Water is probably the only economic carrier for the quicker acting and relatively non-persistent herbicides such as MCPA, dalapon, amitrole and maleic hydrazide which act most effectively through foliage. Among chemicals which are generally thought of as acting through foliage and are used non-selectively sodium chlorate is also effective through root absorption and the same applies to trichlorobenzoic acids and even to quite an extent to a material like 2,4-D though breakdown does occur on and in the soil before root uptake.

For the weed problems under consideration the foliar absorbed chemicals will be used either alone or in combination with more persistent chemicals at medium or high volume rates; 80 gallons per acre for verge spraying with 2,4-D formulations, about the same volume for dalapon or dalapon mixtures and a minimum of 100 gallons per acre or about 1,000 lb. of water with mixtures ocntaining substituted ureas or triazines.

*Borax Consolidated Ltd., London.

Equipment for application varies from the watering can through knapsack sprayers and a wide range of power operated pumps with auxiliary spraying equipment to helicopters. A knapsack sprayer has rather limited use for industrial weed control and there are only two situations in which it is really useful; the spot treatment of broad leaf weeds or brush with MCPA or 2, 4, 5-T formulations and the treatment of inaccessible ditches with dalapon.

Where large areas are to be treated, anything much larger than an electricity sub-station in fact, pumps with their own power unit or operated from the power take-off of a tractor or Land Rover are required. Of some interest in this connection are specially designed booms, lances and other equipment for treating petroleum or timber storage areas, ditches and verges. When insoluble organic herbicides are used recirculation of the spray solution is the method most frequently adopted to keep the material in suspension. Hydraulic agitation is satisfactory provided the pump has sufficient volume to recirculate the spray at about 10% of the tank capacity per minute in addition to supplying the desired number of nozzles. Specially designed seals on centrifugal pumps and rollers which will stand up to a fair amount of abrasion on smaller rollervane pumps are also required in applying insoluble suspensions of most organic herbicides.

Root absorbed herbicides

The chemicals used for total weed control today are more often than not substituted ureas, triazines, sodium chlorate, borates and in some countries, TCA, all of which act through the soil. This means that other carriers than water can be used. None of these chemicals will take effect until a fair amount of rain has carried them into the soil. About half an inch of rain, equivalent to rather more than 10,000 gallons of water per acre is required to carry them into the top soil. Sodium chlorate is the only one of the chemicals mentioned which will still be reasonably effective in the absence of rain.

Sodium chlorate also provides the first well-known example of a formulation or mixture applied dry with a carrier other than water. Ih this case sodium carbonate, other inorganic salts and even sand can be mixed with chlorate to give a dusting powder which is convenient for dry application from a suitable shaker tin. Dusts however have disadvantages; they are bulky, difficult to apply at a specific rate, subject to drift and hardly suitable for large areas with the dusting equipment commercially available.

Equipment for application is the key to the use of other carriers than water and there is little doubt that granular herbicides would have made little headway in the absence of suitable equipment. In fact for agricultural use it is this very lack which is one of the main factors holding up a more widespread use of granular materials on cropland. For the application of total or industrial granular herbicides the basis of suitable application equipment was already present in the small, spinning plate spreader for applying seed or fertiliser. With slight adaptation this machine has filled the gap between the watering can and power-operated spraying equipment. To the user the granular herbicide really has one advantage which is ease of application. To quote some no doubt optimistic statistics from the U.S.A. it is possible for one man with one spreader costing between £5 and £10 to treat an area of 10,000 sq. ft. in ten minutes. The rate of application can be accurately controlled by opening or closing a shutter at the base of the hopper the granules falling through the shutter on to a spinning disc.

Cost of granular herbicides

At present granular herbicides generally cost more than formulations for spray use. This may be because the manufacturer tells us we are getting some unique combination of chemicals or because granular herbicides cost more to manufacture. However, it should not cost significantly more to formulate a granule with clay or cheap inorganic salts than to make a wettable powder. Freight costs, it is true, will be higher with the granular material. If it is more expensive than the equivalent amount of herbicide formulated as a wettable powder, the user has to save on labour or equipment costs in the actual application.

That this is possible in practice is best illustrated by the widespread adoption of granular herbicides in industry. About 500 tons of granular total herbicides will be used in 1961 in Great Britain. If some of the more elaborate power-operated spraying equipment which is now being developed for granules is as expensive as power-operated spraying equipment its use will only be justified where there is a shortage of water. This situation can arise and a good example is from the U.S.A. or Canada where granular herbicides are being used for brush control in difficult country. Under such conditions a granular material taken up by roots also penetrates foliage more effectively than a spray. The choice of application method here seems to lie between a teaspoon and a helicopter. Another situation in which granules can be very easily applied is in controlling submerged weeds in water though 2, 4-D granules appear to have been more successful for this purpose in the U.S.A. than elsewhere.

Equipment in relation to site

Apart from the type of herbicide used, the location of a weed problem—where the ground is and where the weeds are growing on the ground—is likely to be the main factor in determining whether a spray or granular

material is more suitable and what equipment should be used. Railways, the largest users of total herbicides in any country, have a unique problem in weed control on their running tracks. Modern equipment for railways is capable of spraying up to 100 miles of track at 25 miles an hour using two or even three different formulations one of which for example, can be applied in the cess at a particular rate and another on the track at a lower rate. Organic herbicides are generally applied in Great Britain through metering pumps set to deliver into a water or chlorate spray a fixed amount of organic material per acre. While electrification and the use of diesel traction may set railways some problems in providing water for weed spraying, the use of granular herbicides for running tracks poses even more difficult problems. To treat 100 miles of track 16 feet wide (about 200 acres) would require at the very least 10 tons of granules and more probably 20 tons to give a reasonable coverage. It is true to say that four or five times as much water would be required by weight, but techniques for handling water in bulk are better developed than those methods which have so far been introduced for granular materials.

Sites where granules are useful

Finally, brief reference can be made to other sites where either sprays or granules seem particularly suitable and to equipment for application. On pipe tracks, busy rail sidings and other areas difficult to treat with sprays, a granular material has obvious advantages. On some electricity sites access to ground around high voltage equipment is limited and there seems to be scope for a device such as a pneumatically-operated pellet gun which will throw granules for some distance. Local authorities have difficult problems in controlling weeds growing in cracks between paving stones, between kerb and pavement or spread over the kerb into drainage channels. Contact sprays are more likely to be of use in such situations since it is difficult to put root absorbed herbicides into the soil in the root zone.

This article formed the basis of a paper delivered by the author at the Industrial Weed Control Conference in London in June.

CONTROL OF CEREAL PESTS IN BRITAIN

By J. L. HUNT*

Wireworm, wheatbulb fly, frit fly and leatherjackets are the important insect pests of cereals in Britain. This article describes some methods used for dealing with them.

SINCE PRE-WAR DAYS, the production of grain in the United Kingdom has nearly doubled. This notable increase in productivity is attributed mainly to the higher yield potential of modern cereal varieties and the more generous fertiliser treatment which they now receive, but the wide spread-application of herbicides to prevent weed competition and of insecticides to protect the crop against insect pests are also important contributory factors to higher production.

Cereal pests of particular economic importance in the UK are wheat bulb fly, wireworms, frit fly and leatherjackets. Before the introduction of chlorinated hydrocarbon insecticides, control of these pests largely amounted to taking avoiding action by appropriate choice of land for the cereal crop, and by adopting various cultural means designed to limit the scale of infestation and enable the crop to withstand attack. The only chemical control measures adopted to any extent was the use of Paris Green/bran baits to destroy leatherjackets.

Since the war, DDT, y-BHC, aldrin, dieldrin and heptachlor have become available for use in various ways, and the situation has changed completely. These insecticides have replaced Paris Green for use in bran baits to destroy leatherjackets, and they are also widely used in low volume sprays against leatherjackets and frit fly. Aldrin is also incorporated in compound fertilisers to control wheat bulb fly, but the most outstanding development in the field of cereal pest control has been insecticidal seed dressing, the use of which against wheat bulb fly and wireworm is now the rule rather than the exception. This method of control appeals strongly to the farmer on the grounds of low cost and convenience.

Liquid seed treatment

Until recently, only powder seed dressings containing organomercurial compounds for disinfection against seed-borne diseases, and BHC, aldrin, dieldrin and heptachlor as the insecticidal component, have been used in this country, the insecticide being applied at 0.02-0.06 per cent. of the weight of seed. In 1959, Shell Chemical Co. pioneered the technique of liquid seed treatment in the UK, and by arrangement with Casco Limited, of Sweden, introduced the liquid organo-mercurial compound Panogen, together with Astex, a liquid formulation of dieldrin. Other liquid preparations containing aldrin and heptachlor quickly followed, and it seems probable that liquid seed treatment will increase in popularity.

Within certain limits, referred to later, insecticidal seed dressings have proved effective protectants of cereals in the early stages of growth and, generally speaking, aldrin, dieldrin, heptachlor and BHC are of approximately equal efficiency.

As previously mentioned, the insect pests of cereals which are of particular economic importance in Britain wireworms, *Agriotes spp.*, wheat bulb fly, *Leptohylemyia coarctata*, frit fly, *Oscinella frit* and leatherjackets, *Tipula spp*.

The crop sustains damage by wireworms in the early stages of growth, mainly in the spring, oats and spring wheat being particularly susceptible.

Ploughing pasture for crops

The need for increased home food production during and immediately after the war necessitated a substantial increase in our arable acreage, and involved a large scale programme of ploughing out permanent pasture, much of which was heavily infested with wireworm. The general pattern of British farming has now become more stabilised, with a comparatively constant ratio between grass and arable cropping. The reduced acreage of

*Shell Chemical Co., London.

permanent grass which is now ploughed foı arable cropping, and the extensive use of aldrin and dieldrin for control of soil pests in recent years have resulted in the wireworm becoming a pest of considerably less economic importance, but farmers still like to take appropriate steps to insure against damage to their cereals, sugar beet and potatoes.

The insecticidal seed dressing, applied together with an organo-mercurial seed disinfectant, is the standard measure of control adopted. Provided the wireworm population is not too high, this seed treatment will usually give adequate protection of the cereal crop in the seedling stage and enable it to withstand limited attacks after the deterrent affect has worn off. Heavy infestation at this stage may, however, cause severage damage.

The effects of insecticidal seed dressings on the yield of cereals and on the wireworm population have been studied at Rothamsted Experimental station. An experiment with winter wheat carried out over a two-year period compare the effects of BHC seed dressings with BHC broadcast over the ground before drilling and combine drilling with the seed. It was found that the seed dressing increased the yield in the first year, but had no residual effect in the second and no significant effect on wireworm population. On the other hand, the much larger quantities of insecticide broadcast and combine-drilled gave substantial yield increases in the first and second year and appreciably reduced wireworm population over the two-year period. Aldrin combine-drilled and broadcast had a similar effect.

A male wheat bulb fly (Leptohylemyia coarctata *Fall*). *This insect is a serious pest of winter wheat in many parts of Britain.*

Right: Examples of the type of damage suffered by seedlings of winter oats caused by frit fly (Oscinella frit L.)

It would seem therefore that insecticidal seed dressings have mainly a deterrent effect against wireworms and that this effect is of short duration. There is evidence however that seed dressings can kill wireworms is they attack the ungerminated or newly germinated seed. This is most likely to occur with late sown crops, whereas with early sown crops the effect of the seed dressing will have largely worn off by the time the wireworms become active, and they will tend to attack the shoot. In this latter case, they may be deterred by insecticide translocated to the shoot, but they will not be killed.

It can be concluded that seed dressings are appropriate for use where wireworm populations are low, and this applies in most cases at the present time; but with heavy infestations, combine-drilling or broadcasting of aldrin, or the use of a fertiliser containing aldrin, should be adopted.

Wheat bulb fly

Wheat bulb fly is a serious pest of winter wheat in many parts of the country, particularly East Anglia and Lincolnshire, and until fairly recently an effective means of chemical control has not been available. Credit for rectifying this deficiency is due particularly to Dr. H. C. Gough and his colleagues in the National Agricultural Advisory Service and to Rothamsted Experimental Station, who

have carried out a well planned and co-ordinated programme of investigations and field trials during the last few years. These investigations, supported by large-scale extension trials, have demonstrated that a considerable measure of control of wheat bulb fly may be obtained by the use of aldrin, dieldrin, heptachlor and BHC seed dressings, and also by combine-drilling aldrin incorporated in fertiliser. Seed dressing is usually the preferred method, being more effective and cheaper. A higher rate of dressing is employed for wheat bulb fly control than for wire-worm—0.4-0.6 per cent. of insecticide to weight of seed, compared wiht 0.2 per cent.—and this dressing against wheat bulb fly will also, of course, control wireworm.

Wheat bulb fly eggs are laid in the soil in August and September, some six months before they hatch, and the larvae reach the plant from near the soil surface. It is unlikely, therefore, that they are killed by contact with the seed, to any apprecicble extent, except with very shallow drilling. Some larvae may be destroyed by fumigant action or by contact with insecticide picked up by roots and shoots emerging from the germinating seed, but the toxic effect is thought to arise mainly from insecticide translocated systematically from seed to shoot. It is now established that aldrin, dieldrin and heptachlor used as seed dressings have systemic action, and that although a wheat bulb fly larva may destroy the first shoot of the young wheat plant, it will be killed before doing further damage.

Frit fly

Oats are particularly susceptible to damage by frit fly, the seedling plant being attacked by the first generation of maggots and the developing grain by the second generation. Winter wheat sown after an infested ryegrass ley may also be severely damaged and young leys are frequent may also be severely damaged and young leys are frequently attacked in the seedling stage. Frit fly is also the principal pest of maize.

The seed dressing technique has proved to be unsuitable for controlling frit fly. A probable explanation of this is that frit fly eggs are laid both on the plant and in the soil. Larvae hatching from eggs laid on the plant will not come in contact with the insecticide and those hatching from eggs laid in the soil enter the plant at soil level, well above the seed. Experiments with dieldrin dressed seed sown at various depths have shown that a partial kill of larvae is obtained from very shallow sowing, but this is impracticable.

However, it is possible to obtain a fair and sometimes a good measure of control of frit fly, by spraying with dieldrin or DDT emulsion when oats are in the one-to-four leaf stage in early May. With good timing, one dieldrin spray (0.5 per cent. dieldrin in 25 gal. of water per acre) is effective, and it will often be possible to combine this insecticide spray with an application of MCPA to control weeds. The control obtained against frit fly at this stage will often reduce the severity of later attacks by the second generation.

Spraying maize with dieldrin emulsion (0.5 per cent. dieldrin per acre) has also proved effective and is recommended as a routine application. The spray should be applied as soon as the first seedlings emerge and repeated 10-14 days later. High volume application is necessary to wash the insecticide down to the germinating seeds. A placement spray directed on to the rows of seedlings is often used.

Leatherjackets

As with frit fly, seed dressings are ineffectual against leatherjackets, which are sporadic in their attacks, but often devastate a crop in a very short space of time. Cereals grown after a ley are particularly vulnerable, and the risk of infestation in this case can be minimised by early ploughing of the leys before egg laying starts.

Two alternative remedies against leatherjackets are available—spraying with DDT, aldrin or dieldrin emulsions, or broadcasting insecticide bran baits. The former method is more popular with farmers who possess crop spraying machines because of its convenience and speed of operation, but the success of spraying is largely dependent upon the weather. In fairly warm, damp weather, a good control may be expected, but results are often less satisfactory in cold, dry conditions. Spraying in late afternoon or evening will often give improved results. Here again, it may be feasible to apply a combined insecticide/herbicide spray if the corn is at the right stage for the latter application.

The use of broadcast baits against leatherjackets is on the whole a more reliable method of control and, as previously mentioned, the old remedy of Paris Green and bran has now been largely superseded by baits of bran with one of the chlorinated hydrocarbon insecticides: $1\frac{1}{2}$oz. of aldrin or dieldrin, in the form of dust, wettable powder or emulsion, mixed with 25lb. of moist bran and broadcast evenly over the crop at the rate of 35-40lb. per acre will usually give a reliable control. Whatever method of control is employed, it is essential to take prompt action at the first signs of attack if serious damage and loss of crop is to be avoided.

It should be noted that if aldrin is applied broadcast to the soil before sowing a cereal crop against wireworm, leatherjackets will also be controlled, and if a high infestation of leatherjackets is anticipated, this pre-sowing treatment is worth consideration.

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THE IN SITU TREATMENT OF DRY ROT

by A. A. Tyrer

A paper read at the recent annual conference of the British Wood Preserving Association at Cambridge

CONSIDERATION of the in situ treatment of dry rot in this present age when "one expert has estimated that repairs to buildings affected by dry rot have cost the country a total of about £20 million a year" involves the problem of preserving the structural and joinery timbers, not only in the churches, buildings and dwelling houses erected prior to the first World War, but also in the 7,800,000 houses built during the period 1921—60.

A recently completed analysis of some 12,886 property surveys carried out in the past year is interesting in relation to the overall problem of fungal decay in buildings in the U.K. The surveys were largely instigated by owner occupiers but 38.9 per cent of the total were carried out as a result of a change in ownership. The figures are quoted (see Table 1) not because it is felt they can be directly related to the total number of buildings in the U.K. but rather to emphasise the magnitude of the incidence and resultant damage associated with fungal decay of structural timber.

Of the various species of fungi causing decay in timber, the *in situ* servicing company is mainly concerned with three:

Merulius lacrymans (Wulf.) Fr., the dry rot fungus;
Coniophora cerebella Pers., the cellar fungus, (wet rot);
Poria spp., the pore or mine fungus.

The treatment of decay caused by wood rotting fungi requires an understanding of the biology of, and an ability to differentiate accurately between, the various species encountered, as the remedial works will largely depend upon the particular fungus present. For this reason some notes upon the biology of these fungi are relevant to a fuller understanding of the problems of *in situ* treatment.

The dry rot fungus

The fungus plant consists of fine branching threads termed hyphae, which penetrate into the wood and feed upon it by extracting those constituents which the fungus can utilise for its nutriment. This brings about marked changes in the wood which becomes lighter in weight, and this loss of wood substance causes deep longitudinal and transverse cracks to be formed, breaking up the wood into cuboidal pieces, which are sometimes quite large, measuring up to 5 cms. long. In an advanced stage the wood crumbles readily into a dry powder, giving rise to the popular name of "dry rot".

The fungus usually spreads over the external surface of the wood as a mass of hyphae, termed mycelium, and under very moist conditions this takes the form of a soft white sheet of the texture of cotton wool. In less humid atmospheres, or at a later stage of growth, the mycelium forms a silvery grey skin over the surface and, as the mycelium ages, tinges of lilac and patches of bright lemon-yellow usually appear. Sometimes, especially when the free surfaces of the wood are painted, as in door architraves and skirtings, there may be no external mycelium evident, and not until a late stage of decay are the first signs of attack shown by the buckling and cracking of the wood.

A characteristic of this fungus is its ability to form conducting strands which may be fine or stout, and up to 8 mm. in diameter. These strands are composed of specialised hyphae and contain tubes which conduct

TABLE 1

Analysis of 12,886 property surveys in the U.K.

Types of Property Surveyed	
Private dwelling houses	83.2
Commercial premises	8.9
Churches, historic buildings	5.3
Farms, country estates	2.6
Age of Property	
Pre-1919	59.0
1920-1939	37.2
1940-1960	3.8
Incidence of Fungal Decay	
Dry rot	16.6
Wet rot	26.9
Insect Damage Allied with Fungal Attack	
Weevils	4.8
Death watch beetle	5.5

General manager, Woodworm and Dry Rot Control Ltd.

water enabling an attack in a damp part of a building to spread to neighbouring woodwork which may be comparatively dry. The strands are also capable of penetrating brickwork and passing over inert substances such as stone and metal and the fungus is thus able to spread to other timber in the vicinity.

By the chemical breakdown of the cellulose in wood, *Merulius* forms its own water, and this is sufficient to ensure suitable conditions for further growth if the source of external moisture is cut off. Normally, and especially in humid conditions, this water is excreted by the fungus for it would otherwise render the wood too moist for further development. The excess moisture appears in the form of drops on the surface of the mycelium, and from these the fungus derives its name *lacrymans*, or "weeping". When the fungus has reached a certain stage of maturity it usually forms fruit-bodies or sporophores from which are released minute spores. The fruit-bodies of *Merulius* vary greatly in shape and configuration of the spore layer according to the positions in which they develop, but they are readily distinguished by their tough texture and the characteristic rusty-red colour of the corrugated spore forming layer. When growing on a horizontal surface the fruit-body consists typically of a thick fleshy plate and the spore layer is of shallow pores, but on vertical surfaces the fruit-body usually develops as a short thick bracket and the spore layer has elongated folds. When young it is pale grey, with tinges of lilac but as the spores develop the reproductive layer assumes a bright rusty-red colour.

The size of the fruit-bodies varies from 2 in. to 3 or 4 ft. in diameter, and on ageing they become hard and leathery, but never woody. Millions of spores are given off from the fruit-body visible to the naked eye as a rusty-red dust. Being very light they are readily blown about by the air, and when they alight on damp and ill-ventilated wood they germinate to produce the thread-like hyphae, which penetrate into the wood and set up a new attack.

Merulius lacrymans cannot develop in wood containing less than about 25 per cent moisture and the optimum moisture content for its growth is probably between 30 and 40 per cent. Poor ventilation and a high atmospheric humidity are also essential for its rapid spread throughout buildings, and in such premises the familiar "mushroom-like" odour associated with this fungus can be detected. The optimum temperature for growth is about 23°C. but the fungus is sensitive to higher temperatures, the maximum for survival being 26°C. A temperature of 40°C. will destroy the fungus in 15 minutes.

Cellar fungus

The cellar fungus requires more moist conditions than does *Merulius lacrymans* and the optimum water content for growth in the wood is said to be between 50-60 per cent. For this reason, decay caused by *C.cerebella* may be referred to as "wet rot". As would be expected it is correspondingly sensitive to drying and all activity of this fungus ceases when the source of moisture is removed as, unlike *Merulius*, it does not appear able to utilise to the same extent the water obtained by the breakdown of cellulose and cannot render wood sufficiently moist for continued development. Because of this it is relatively more simple to control than *Merulius lacrymans* and less likely to cause such serious damage. *Coniophora cerebella* attacks both hardwoods and softwoods, although the latter are probably more readily attacked. Under satisfactory growth conditions it will cause slow decay even in such durable woods as oak, yew and jarrah. When an attack by *C. cerebella* is in its early stages the wood assumes a pronounced discolouration at the edges of the decayed portion where yellowish-brown streaks or patches occur. Later the wood becomes lighter in weight and considerably darkened in colour, and in the final stage it may become a very dark brown or even brownish-black. On drying, the wood shrinks, and cracks occur which mainly run along the grain. Although cross-cracks at right angles do develop they are rarely so pronounced as when the rot has been brought about by an attack of *Merulius lacrymans* and when cuboidal cracking does occur the individual pieces into which the wood breaks are not normally as large as those formed by true dry rot. In the decay caused by *C. cerebella* very often the damage remains hidden by a superficial layer of practically sound wood which only reveals the decay beneath when broken. When wood is severely decayed it becomes brittle and readily crumbles to powder between the fingers.

Unlike *M. lacrymans*, *Coniophora cerebella* never forms a thick mycelium, but may produce a thin yellowish-brown skin. Strands are usually to be found somewhere on the surface of the decayed wood and these, at first light in colour, soon darken to brown, but *never* become as thick as those of *Merulius*, are seldom thicker than stout twine, and do not penetrate into brickwork. The strands often appear as a characteristic dark fern-like growth which, however, may spread over the surface of damp plaster.

The pore or mine fungus

Although often classed as "dry rot", *Poria* does not spread so readily to drier parts of buildings as *Merulius lacrymans*. Brickwork is not penetrated deeply and methods of eradication are consequently simpler than when *Merulius* is involved.

Poria spp. is able to grow over a wider range of temperature than *Merulius lacrymans* and so is found in mines in which the average temperature is too high to

support a growth of dry rot. The optimum temperature at which the pore fungus develops is 27°C. whilst the maximum temperature is about 36°C. It also requires rather moister conditions than *Merulius* for its development and is, therefore, more easily checked by drying. Softwoods are frequently attacked and in these *Poria* can cause a fairly rapid loss of weight.

The typical decay caused by *Poria spp.* closely resembles that caused by *Merulius lacrymans*. The wood tends to become slightly darker and cuboidal cracking is produced by cracks forming along and across the grain but these are not usually as deep or as pronounced as in those caused by *Merulius*. Unlike those of dry rot, however, the sheets of mycelium formed by *Poria* on the surface of the wood always remain white. The branching strands which are produced never become as thick as those developed by *Merulius* and always remain flexible, those of the latter becoming brittle when dry.

Survey technique

Successful *in situ* treatment of dry rot is entirely dependent upon an accurate survey having been made in the first instance and for this reason it is worth pausing for a moment to consider some of the qualities required of a surveyor engaged in the preservative treatment of fungal decay in relation to the three main purposes of the inspection to be made:

1. *Identifying the nature and assessing the extent and degree of timber decay arising from attack by wood rotting fungi.* The surveyor must have knowledge not only of the various factors causing wood decay, but also of the biology of wood rotting fungi sufficient for him to identify the particular species of fungus causing the decay to enable him to deal properly with.

2. *Specifying the appropriate eradication and reinstatement works.* Appreciation of the structural problems involved in the removal of decayed timber from infected buildings and in its renewal requires a comprehensive knowledge of building design and construction and a sound practical experience of dealing with the problems of maintenance of existing buildings rather than with those of new construction. Certainly, the complete range of the surveyor's technical knowledge and experience will be required in full measure in dealing with the problems confronting him during the course of the survey.

3. *Preparing estimates of the costs of carrying out those works.* Any person suffering damage to his property by dry rot has only one question in mind: "What is the cost of repair?". The answer to this question is always difficult but because of its importance to the property owner the survey requires to be executed in a manner which will enable the surveyor to give as accurate as possible an indication of the cost at the earliest possible stage. A precise cost figure is, however, not possible until exposure of the infected area is complete.

Any examination of a building for the purposes of ascertaining the presence of dry rot, *Merulius lacrymans*, should commence from the outside. A preliminary study of the external character, age and maintenance condition of the property, and of its position in relation to the general configuration of the land can often provide most useful information. Examination of the roof, downpipes, hopper heads, gutters; the condition of pointing, rendering, brickwork or masonry; the level of the soil in relation to damp courses and air bricks are all points worthy of observation and, if necessary, of more detailed enquiry, as they can provide quite significant indications of the entry of water into the building and, therefore, of parts of the structure calling for special investigation.

Only when this external inspection is complete should the interior examination of the building be undertaken. The sequence of operations involved in this examination must, of necessity, be systematic so that each location of inspection is properly established and the risk of overlooking any area eliminated. It should be based upon the firm knowledge that decay of timbers in buildings by *Merulius lacrymans* is always caused by the penetration of moisture, either in liquid or vapour form, to timbers in conditions of inadequate ventilation and if, therefore, such conditions are present, the possibility of an attack must be investigated by tracing from the likely cause, frequently revealed, as stated previously, by the external examination.

To determine the presence of an attack the timbers within each location of inspection must be examined carefully for signs of decay, i.e. the presence of surface buckling, particularly of joinery timbers, or of a reaction to a prodding test both of which are indicative of sub-surface decay. Underfloor inspections are essential and in the case of large section timbers it is often necessary to examine the shavings from suitably selected drillings to ascertain the presence or absence of internal decay. Brown colouration of the timber, cuboidal cracking, hyphae or mycelium will immediately reveal the nature of the problem with which one is faced, whilst the presence of spore dust and sprorphores will indicate an attack of some considerable maturity.

Having ascertained the presence of *Merulius lacrymans*, the extent of decay must be determined and this requires the fullest possible examination. In so doing there are two aspects of the biology of the fungus which should be uppermost in the mind of the surveyor:

1. The quite incredible power of the hyphal strands to penetrate hair cracks in the mortar joints of brick and masonry walls in searching out further timber to attack.

2. The ability to form water and to convey it by means of the specialised conducting strands to timber in a perfectly normal state of moisture content thereby

A particular severe attack of Merulius Lacrymans.

providing the additional moisture necessary for the further establishment of the fungus.

Wherever evidence of an attack is observed it is useful to consider that point as being the central point of a sphere having a radius of about 3 ft., and for an examination to be made within the area of this sphere in all planes and in all directions, since it is here where there are likely to be other points of attack. It follows, therefore, that this examination is not concerned solely with timber and is more than likely to involve the examination of inert substances such as wall plaster, brickwork, masonry and similar materials. Wherever such continued evidence is discovered, a further area covered by a second similar sphere should then be the subject of investigation, bearing in mind the considerations mentioned above. The investigation should then continue until the complete limits of the attack have been determined and the structural conditions causing the onset of the initial decay have been traced. In the case of dry rot, *Merulius lacrymans*, that cause may be at some considerable distance from the site of the evident attack, whereas in the case of wet rot the cause is almost certainly closely related.

Unfortunately, it is rarely possible during the initial survey to ascertain the full extent of an attack and it is often necessary to specify preliminary exposure works to be carried out so that the infected area can be determined sufficiently for the surveyor to prepare a comprehensive eradication and reinstatement tpecificationi In preparing the specification, the surveyor requires also to bear in mind that any report dealing with *Merulius lacrymans* or, indeed, any form of fungal decay, cannot be considered adequate or even complete unless that report states quite clearly both the cause and source of attack and specifies the works which are necessary for the removal of that cause.

Treatment technique

As is similarly the case with the surveyor, the *in situ* servicing company must provide and ensure the highest possible standards of technological training and competence of its operative staff engaged in remedial work. *In situ* service operators are required to carry out eradication works in four phases, each of which is distinct and requires the workman to have an adequate understanding of the particular fungus concerned if those works are to be satisfactory in all respects. These phases are exposure, sterilisation, repair of the cause, and reinstatement.

It is, of course, possible that the two latter phases become closely integrated in practice but, for the purpose of clarity, it is more convenient for them to be considered separately.

Exposure. The extent to which the exposure of the infected area is to be carried out will already have been indicated by the surveyor and, prior to the commencement of these works, the operatives should take adequate precautions to reduce to a minimum the inconvenience which inevitably will be caused to the occupier. Care, therefore, needs to be exercised in protection of the property from the point of entry to the area of treatment, combined with sealing off the area from the remainder of the building. Paying due regard to the necessity of retaining structural stability of the fabric of the building, timber in the affected area should be cut away to an extent of about 3 ft. beyond the last visible evidence of fungal decay. Similarly, wall plaster found to be penetrated by hyphal strands should be hacked away to the same extent, considerable care being exercised by the operatives in removing from the walls wooden fixing plugs, lintols and bonding timbers. In those cases where an earth sub-site beneath a ground floor is found to be heavily covered with deposits of spore dust and, possibly due to the presence of timber debris on the earth, heavy growths of mycelium and hyphae are present, it will be necessary to excavate some 3 to 4 in. of that soil. In short the whole area of attack should be opened up to the limits previously described and the decayed material removed from the building by the shortest possible route and, in the case of timber, burned.

It is impossible to overstress the importance of the correct disposal of such decayed material because, only by so doing, can one ensure that further infection is not spread to other areas, or indeed, other buildings.

Having fully exposed the area of attack all surfaces in walling, partitions, sleeper walls, surface concrete and also all remaining timber, and any steel or pipe work within the area up to a radius of about 5 ft. from the furthest extent of suspected infection should be given a light spraying with fungicide and then thoroughly cleaned with a wire brush. The dust and debris resultant upon this operation should be collected, removed and burned.

Sterilisation. It is recorded earlier in this paper that *Merulius lacrymans* is susceptible to heat and that the maximum temperature for survival is 26°C. Similar observations appear in almost all the available literature on the subject and the application of heat is a well accepted part of treatment practice. Such application of heat to wall and oversite areas can, however, at best provide adequate sterilisation of the surfaces only of such areas and, whilst most certainly useful in this respect, cannot be relied upon as an effective method of control. Rather should one look upon the use of heat as a means of evaporating moisture from the wall and oversite areas and as a preliminary procedure to the main sterilisation process which is the application of fungicidal fluids. By removing moisture from the materials encountered one is facilitating the entry of the fungicide thereby providing complete sterilisation. The degree in which hyphae and mycelium were present upon wall and site surfaces will control the method by which the fungicidal fluid is applied and, in the case of there being slight evidence, control will normally be obtained by a surface application. Mass brickwork found to be heavily penetrated to an extent beyond the range of surface applications of heat and fluid sterilisation will necessitate the fungicidal fluid being introduced by means of irrigation. It would, however, be quite uneconomic, impracticable and unnecessary to attempt to irrigate the whole of the brickwork to an extent where one has virtually achieved complete saturation of that brickwork or masonry.

The object of irrigation is quite simply to "lock up" any living fungal growth which may be known or suspected to be inaccessibly present within a structural mass. This involves the creation of a toxic barrier or box and is achieved by means of drilling the wall surface at close centres around the perimeter of the exposed area on both sides of the wall. The fungicidal fluid should be irrigated into the drillings around the perimeter to an extent sufficient to ensure the substantial saturation of the brick or masonry mass within the confines of the perimeter band. The enclosed plan surface areas on either side of the wall can then be effectively treated by a surface application carried out on both sides wherever possible.

The production of the toxic box must, of course, be carried out with due regard to considerations of structural stability.

Sterilisation of wall surfaces can also be achieved by the use of zinc oxychloride which is available either as a cement, to be incorporated in wall plaster, or as a paint, for application to bare brick or masonry walls. These materials are best suited to supplementing the normal "toxic box" by providing additional protection to those areas of walling which will come in contact with, or be adjacent to, replacement timber.

Reinstatement. Sound timber adjacent to the exposed area should be thoroughly treated with a suitable fungicide by surface application following which one is in a position to undertake the complete reinstatement works in the, by now, sterilised area of treatment. In view however, of the fact that *Merulius lacrymans* develops in conditions of dampness combined with inadequate ventilation it would be very unwise and certainly poor practice to reintroduce into treated walls bonding timbers, wooden lintols or fixing blocks, where these can be avoided quite easily by the use of inert materials.

All new timber used for reinstatement purposes obviously needs a preservative treatment. That treatment can well be given by pressure impregnation methods. Equally, however, actual experience of thousands of successful dry rot eradication treatments have shown that treatment with a 5 per cent P.S.P. solution by liberal surface application and immersion of the cut end grains given during the course of the works provides effective protection. This pre-treatment of new timber is a vitally important part of any remedial works and requires to be carried out *after* the timbers have been cut to size for the purpose they are to serve. Cut end grains should be immersed so that the lateral penetration of the surface application may be supplemented by longitudinal absorption at the point of greatest susceptibility to the onset of fungal decay.

The provision of chemical preservation described above requires supplementation by mechanical protection of the timber against a future possibility of either rising and/or penetrating moisture from the fabric of the building. This is achieved, for example, by removing any defective damp courses from sleeper walls and laying new lead-lined bitumen damp proof material prior to fixing replacement timbers. In special circumstances, the use of cold rubberised bitumen solutions can play an important and effective part.

Correcting the cause

In determining the extent of the attack by *Merulius lacrymans* the cause of the attack will have been traced and must now be corrected. That cause could be quite simply defective gutters or downpipes and rectification

might involve localised repair or complete renewal, depending upon the particular circumstances. Quite frequently, however, the cause of the attack can be traced either to a faulty damp course or to its absence. Many older properties lacking damp courses are free from rising damp by virtue of the nature and slope of the soil and by the existence of properly constructed and well maintained systems of rainwater and surface water drainage. Damp conditions occurring in such circumstances can usually be traced to some recent damage or obstructions to the drainage arrangements, the repair or removal of which suffices to correct the trouble.

The insertion of horizontal damp courses in walls of up to 21 in. in thickness where (1) they have not previously existed, or (2) existing areas have become faulty, is by normal methods a difficult and expensive process but one which, nevertheless is necessary on occasions. In walls exceeding 21 in. in thickness, however, all normal methods of inserting a horizontal D.P.C. are completely impracticable and, indeed, virtually impossible. There are however, possibilities current at the time of writing this paper that the reintroduction into this country of improving electro-osmotic damp proofing techniques may be capable of removing much of the difficulty and expense from this important operation, thereby providing an efficient means of controlling rising damp due to capillarity in walls of *any* thickness. The principles of electro-osmotic damp control are based upon the fact that the capillary movement of water in porous materials against the force of gravity occurs because the water possesses "surface tension" caused by certain electrical relationships between the water and the capillaries. The minute voltages arising from these relationships create electrical potential differences between the water at the various levels reached in the capillaries and the subsoil, i.e. negative potentials in the wall and a positive potential at the subsoil.

Removal of "surface tension" resulting in removal of capillary movement and therefore in removal of rising damp, can be achieved by short circuiting those voltages between a cross sectional plane of a wall and the earth by inserting, at any required D.P.C. level, a series of electrodes at carefully calculated intervals along the length of the wall and linking them together by a common conductor which is connected to earth. This self energised electrostatic field throughout the cross section of the wall provides a barrier above which surface tension will not persist; capillary movement will not, therefore, continue.

Such a system of damp proofing can function equally efficiently in any thickness of wall—in walls of over 21 in. in thickness it will be the only system.

It should, however, be recognised that it may sometimes be impossible in underfloor voids to ensure complete freedom from dampness rising as a vapour and that the presence of this condition is not of itself a threat to exposed timber. Combined damp and inadequate ventilation are the danger and it is imperative to provide additional ventilation. The basic minimum provision of one 9 in. by 6 in. air brick per 7 ft. run of external wall should be increased to extents that will ensure an adequate flow of ventilation currents throughout the underfloor area. Such vents should be placed as high as possible above ground level in relation to internal floor levels. Sleeper walls should be honeycombed and special ducting may be required to avoid blind spots created by areas of solid floors.

Prevention of dry rot in buildings

Consideration of the inevitable and far reaching works required for the successful treatment of *Merulius lacrymans* suggests more than a grain of truth in the old saying, "Prevention is better than cure". It is equally true that any discussion upon eradication measures would be incomplete in the absence of comment upon the measures which should be taken to avoid dry rot in buildings. These measures are twofold in their application in so far that separate considerations are required in their application in respect of existing as opposed to new buildings.

Existing buildings

It is seldom possible either (1) to improve the design of the structure, or (2) significantly to improve the standard of construction, if only for the practical difficulties and economic reasons involved. Rather should the preventive measures be directed to excluding from the buildings those conditions conductive to the onset of fungal decay. Those measures may be summarised as follows:

Rising dampness—Soil levels should be maintained well below the damp course and cleared of shrubbery or climbing plants, and sub-floor ventilation should be improved to a standard not less than that quoted earlier in this paper. Preventive measures for ground floors should always bear in mind that *Merulius lacrymans* flourishes in conditions of dampness and inadequate ventilation. Some dampness of the underfloor area may well be an unsurmountable problem—inadequate ventilation is inexcusable in considering precautionary control measures.

Penetrating Dampness—Maintenance of the building requires to be of a satisfactory standard in all respects. Particular attention should be paid to roofing and flashings; gutters, downpipes; pointing or rendering of wall surfaces and painting of exposed timber surfaces.

Flood Damage—Any person connected with the

preservation of timber cannot fail to be concerned by the national tragedies of 1960 and of the consequent possibilities of severe cases of fungal decay occurring in buildings within the affected areas.

Fortunately, much sound advice has been widely publicised for the guidance of householders and it is not out of place to refer to this aspect of dry rot prevention.

Floor coverings should be lifted, dried and stored until the flooring timbers are completely dry. A sufficient number of the floor boards should be raised to enable water and silt to be removed entirely and air bricks in external walls cleared of debris.

Silt which has raised external soil levels adjacent to walls should be removed and the levels restored well below the damp course and, if flooding of the wall cavity above the damp course has occurred, it is necessary to remove bricks to facilitate removal of silt within the cavity. Floor timbers, particularly joist ends, require drying in the shortest reasonably practicable time; a process materially assisted by ensuring a completely free flow of air and the judicious use of fires and heaters.

The possibility of timber decay by *Merulius lacrymans* can be excluded from new buildings by good design, good building construction, and adequate and regular maintenance.

New buildings

It is not, however, within the scope of this paper to discuss in detail design and construction, but rather to indicate the manner in which both can materially assist in overcoming the problem of decay. This can quite simply be stated as the prevention of penetration of dampness, the provision of adequate ventilation and the ability to construct to the standards required to ensure the design requirements are not nullified by malpractice.

Unfortunately, it is not possible either for the architect or the builder to ensure adequate and regular maintenance of a building after completion and it is possible, if not distinctly probable, that deterioration as a result of neglect in maintenance will produce those conditions, already discussed, which are essential for the establishment of fungal decay, and equally possible that ill-advised alterations will produce the same trouble.

It is justifiable, therefore, to consider ways and means of legislating for a probable breakdown in maintenance in order to ensure the prevention of dry rot, at some undetermined future date. To do so must surely involve some consideration of the building material concerned—namely timber.

During the course of the housing booms experienced in this country in the present century softwood timbers have been utilised for structural purposes in some 7,800,000 newly erected dwelling houses. World shortages of timber have been apparent to an extent where the qualities available for building construction have, of necessity, declined and contain ever increasing proportions of sapwood—rich in food material and, as is similarly the case with certain of the wood boring insects, particularly attractive to wood rotting fungi.

The same period has also been one of improvements in timber technology whereby sizes of timbers have shown not inconsiderable reductions in section dimensions with similar reductions in load bearing safety factors. The use of timber of greater sapwood content and of lower sectional size is not significant to these deliberations in so far as it is known, 'there is no consistent difference either in the weight when dry or in the mechanical strength of sapwood and heartwood of the same moisture content.' Such use is, however, significant in that the sapwood is much more attractive to wood rotting fungi and, in view of the lower load bearing safety margins, where decay occurs, there is consequently a greater risk of structural failure. That risk is further enhanced by the potential depredations of the common furniture beetle, *Anobium punctatum* De Geer, over which one cannot exercise control of access to the *in situ* structural timbers.

Fortunately it is true that "the sapwood of softwoods can generally be impregnated with preservatives much more readily than heartwood with the result that where preserved timber is used the sapwood may be as durable or even more durable than the heartwood submitted to the same treatment."

Here then must surely lie the answer to the prevention of dry rot in new buildings—the pre-treatment of structural and joinery timbers. The cost factor is negligible compared with the possible future *in situ* treatment cost, and one ventures to suggest that all concerned with the wood preserving industry will render this country an enormous service by advocating the preservative pre-treatment of what is still the most versatile of building materials—softwood structural timbers.

For their assistance in the preparation of this paper the author wishes to thank his colleagues Dr. N. E. Hicken, Mr. W. J. Holmes and Mr. R. K. Farmer.

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NEWS

research: events: products:

WHO Conference on Onchocerciasis

To discuss problems of control of the Simulium fly, the carrier of an infestation disease called Onchocerciasis, the World Health Organization called an international conference in June at Brazzaville, where the organization has its African regional office. This was the second conference convened by the WHO in Africa, the first being in October 1954.

The natural beauty spots of waterfalls and rapids in the African tropical belt are favourite breeding grounds for several varieties of the Simulium fly. In method of transmission, Onchocerciasis bears a certain resemblance to malaria, although its effects are quite different. Like the malaria-bearing mosquitoe, the female of the Simulium fly species likes to feed on blood, and this is necessary for her when laying eggs. When biting a person infested with Onchocerciasis, the fly will ingest the tiny filarial worm called Onchocerca from the deeper skin layer which she penetrates. This worm, according to medical definition, infests human beings, forming fibrous nodular tumours with encapsulation of the adult worms in the subcutaneous connective tissue. When the fly bites its next victim, not yet infested by the disease, she transmits the microfilariae through her saliva.

While Onchocerciasis is very widespread throughout tropical Africa, and millions of persons are either at risk or actually infested, the incidence appears to be very patchy, rising from spradic cases in some parts to infestation of nearly 100 per cent of the population in others. The governing factor appears to be the prevalence of the Simulium fly vector. A typical picture is presented by the first reach of the Victoria Nile, after its emergence from Lake Victoria, which includes a 50-mile stretch of rapids. This formerly produced countless swarms of Simulium flies which were responsible for an incidence of Onchocerciasis approaching 100 per cent among the adult population in an area of 1800 square miles, and were causing a progressive depopulation. After control was instituted in 1952, the population of two of the most severely infested areas rose from 6,000 to 78,000.

It is in the areas of heavy infestation, evidently, that Onchocerciasis gives rise to blindness, when the microfilariae penetrates to the eye. Authorities believe that this happens only late in the disease, and usually after the earlier infestation has persisted for five or six years or more. "Sudan blindness" and "river blindness", in north Ghana, have both been traced to this cause.

Where circumstances are favourable (as in a previously heavily infested area of Kenya) Onchocerciasis has been eradicated by treating the rivers with larvicides with the object of destroying the Simulium flies. The larvae are very susceptible to DDT, BHC and dieldrin, but (says the WHO) these have had harmful effects on fish in the treated rivers.

Because many of the rivers cut across national boundaries, some measure of agreed control is necessary, and this was the object of the Brazzaville conference recently.

More co-ordination of research needed

A call for increased collaboration on research and development of wood preservation techniques and allied subjects was made last month by Mr. W. E. Vesey, the new president of the British Wood Preserving Association, at the annual convention of the association in Cambridge.

He urged that means "must be found and acknowledged by the Department of Scientific and Industrial Research to ensure that there is no overlapping of work, whether it be financed privately or with government aid. I suggest that while the reorganisation of the Forest Products Research Laboratory and Timber Development Association is in progress, now is the time to establish a liaison committee covering all interested parties.

"I go further by suggesting that while some of these interested parties have direct representation on the steering committee of the D.S.I.R., this liaison committee should have its own representatives to speak for the other bodies directly interested in the programme of work."

Mr. Vesey said that it is in the interests of government and of trade organisations to see that more than one body is not aiming at the same objective in research.

Some 230 delegates and guests attended the convention, which attracted speakers from many interested organisations in Britain, Sweden, Australia, Germany, France, and Yugoslavia. Several of these papers which are of outstanding interest are to be subsequently published in Pest Technology (one is included in this present issue).

BWPA Officers

New officers were elected for the year 1961/62 when the British Wood Preserving Association held its annual general meeting in April in London. The new president of the association is Mr. W. E. Vesey, who takes up the office from Mr. Bernard Hickson. Mr. Vesey is managing director of Christie & Vesey Ltd. He is also chairman of the Drumloist Shipping Co. and of Robert S. Vesey & Co. Ltd.

Elected deputy president of the association for the current year is Mr. C. E. Carey.

Mr. C. S. White was re-elected vice-president and two new vice-presidents were also elected: Mr. L. W. Blundell and Mr. F. P. Robson.

Experts see method of grass control

Chemical control methods of grass growth and weeds were demonstrated recently by Baywood Chemicals Ltd., of London, to more than a hundred highway officials and experts from other organisations.

Along a stretch of the old Roman Akeman Street near Bibury, Gloucestershire, the company has established trial plots in co-operation with Gloucestershire County Council to study the most effective methods of controlling tall grass and weeds, most notably on roadsides. The development of special chemicals which effectively regulate grass growth and control weeds has been carried out by Baywood in close collaboration with the Road Research Laboratory, the Nature Conservancy and other interested bodies.

Maleic hydrazide, a product of Whiffen and Son Ltd., in the form of a water soluble amine salt, is used as the active growth inhibiting agent, making up 25 per cent of Regulox. This is often used in association with Vergemaster, which is a selective weedkiller. By using a mixture of these materials, a combined spraying operation can be carried out for overall control of grass and weed growth.

It has been found that with this combined mixture, only six hours of dry weather after application is necessary to achieve good results. Yet good results have been obtained even after a light rainfall an hour after the spraying operation.

At Bibury this year, the experts saw plots currently under study by the Department of Botany at Bristol University to determine the changes in composition of vegetation after chemical treatment. An encouraging result of this research, says Baywood, is that, far from damaging grass, spraying over successive years, by the removal of weed competition, develops finer textured grass with greater coverage.

"Gyroplane" for aerial spraying

Provision of an economical aerial crop-spraying service is the aim of two British companies who have announced the development of a new autogyro-type craft for this purpose. Called the Agricultural Gyroplane, and demonstrated for the first time last month, it has been developed jointly by D. Napier & Son Ltd. and Pan Britannica Industries Ltd.

In experiments going back more than two years, Napier chose the autogyro as the best basis for the vehicle needed. A striking feature of the Gyroplane is said to be the concentration on a low payload per flight, made possible by the quick refilling offered by the unit.

It has exceptional manoeuvrability over a wide range of speeds, and can be flown safely at low speeds, offering an accurate and economical coverage of irregular shaped fields.

The plane unit is completely self-contained with vehicle and trailer for both towing the Gyroplane and carrying the fuel and spraying compounds. This obviates inability to fly cross-country in bad weather conditions, and reduces the cost of transport to the spraying site.

The companies involved point out that the aircraft at present is essentially in the development stage; it is to be operated by Pan Britannica to make a comprehensive study of operating costs, compared with fixed-wing aircraft. However, the companies say that it can already be calculated that the present machine, based on a 5 to 10 acre payload and quick turnround, will both on capital costs and spraying cost-per-acre, offer a considerable advantage over any fixed-wing agricultural aircraft.

The Agricultural Gyroplane, designed for economical aerial crop-spraying of small areas.

Pan Britannica Industries Ltd. is associated with J. W. Chafer Ltd. of Doncaster, and Crop Culture (Aerial) Ltd., of the Isle of Wight, in this work.

APPOINTMENTS VACANT

PLANT HEALTH INSPECTORS: MINISTRY OF AGRICULTURE, FISHERIES AND FOOD. 8 pensionable posts for men or women at least 25 on 1. 9. 61. Qualifications: normally G.C.E. in at least 5 subjects including 2 at "A" level, or equivalent; sound background knowledge of horticulture, and some formal training at a horticultural college or farm institute. Degree or diploma in horticulture an advantage. National salary scale £983 - £1154. Promotion prospects. Write Civil Service Commission, Burlington Gardens, London, W.1. for application form quoting 5369/61. Closing date 15th September 1961.

ENGINEER required with experience in the **design and manufacture of tractor mounted ground crop spraying machines.** This is a progressive post. Details in fullest confidence to: **The Vigzol Oil Company Limited, Vigzol House, Greenwich, London, S.E.10. Ref. SE/KW.**

Control of Rats and Mice. *By R. A. Davis, Ministry of Agriculture, Fisheries and Food Bulletin No.* 181. (*H.M.S.O., London,* 4*s.* 4*d. post free*).

Rats and mice have been dependent on man for food and shelter for centuries. They gain a great deal from their association whereas we suffer disease and economic loss from it. That rats and mice were our enemies and not our friends has long been recognised, and in the days of Queen Elizabeth I a bounty of one penny was offered "for the heads of everie three rattes or twelve myse".

Control of these pests is now based on a study of their behaviour and the use of chemical rodenticides. Important technical advances have been made in the past twenty years and this new MAFF bulletin replaces the now out-of-print booklet, *Infestation Control, Rats and Mice* published in 1946. It is written primarily for people who have to supervise rodent control operations, and for those who want to delve more deeply into the subject a valuable list of selected publications is given at the end.

The bulletin describes methods of planning and carrying out rodent control operations, and describes such methods of control as poisoning, trapping and fumigation. Details of the compositions of poison baits are given and the most important rodenticides in common use are briefly described. Finally, hygiene and proofing premises against rats are dealt with.

Advances in Pest Control Research. *Interscience Publishers,* 89/90 *Chancery Lane, London, W.C.*2 *price* 94*s*.

Since the publication of the first volume in the "Advances in Pest Control Research" in 1957 a high standard has been set and maintained in this series under the editorship of R. L. Metcalf. The fourth volume in the series, which has just appeared, in no way falls short of this standard.

The main fault to be found with the latest volume is that of the eight papers collected in this volume all but one are concerned with control of insects. Research on pest control is surely advancing on a much broader front than this might indicate.

"Some Fundamental Aspects of Applied Insect Physiology," by Irvin M. Hall, provides a brief, concise review of insect diseases caused by micro-organisms and discusses many points of fundamental importance to entomologists bent on spreading disease among populations of pestiferous insects.

W. F. Barthel reviews the extensive chemical and biological work on synthetic pyrethroids which has already led to the production of insecticides such as allethrin, cyclethrin, furethrin and barthrin.

In his paper on "Selective Toxicity of Insecticides" R. D. O'Brian deals with the problem of ". . . . . how to kill enemies and spare friends". He concludes that bespoke synthesis of selective insecticides has so far proved possible only with organophosphorous compounds but that extensive study of the carbamates should lead to their selective toxicity being put on a rational basis. New toxophores are needed and any compound toxic to mammals presents a starting point for "building in selectivity." The most promising candidate group is the flour acids and their serivatives where a promising start has already been made with fluoraceaphiamide, a selective aphicide.

The paper by Kenneth P. Dubois continues the theme of safe use of insecticides by discussing "Potentiaton of the Toxicity of Organo-Phosphorous Compounds." The results of potentiation tests with about fifty pairs of organo-phosphorous insecticides are described and discussed. Account is also taken of the suggestive finding that tri-orthotolyl phosphate potentiates the toxicity of malathion to rates by inhibiting its detoxification by enzymes.

J. C. Gage writing on "Residue Determination by Cholinesterase Inhibition Analysis" is again concerned with the safe use of insecticides. He deals with the theory and general practice of this method of determining cholinesterase inhibiting chemicals and discusses its possible use for estimation of toxic residues on edible crops.

"Chemical Control of Insect Pests of Domestic Animals." William M. Rogoff approaches this topic from an unusual angle and suggests the use of the word *entomicide* for chemicals which control mites, ticks and insects.

Over the past decade malathion has established itself as one of the most generally useful modern insecticides and D. Spiller provides a most useful and timely "Digest of Available Information on the Insecticide Malathion." He covers its properties in the widest sense and its use for controlling veterinary, domestic, public health, forest, agricultural and stored products pests quoting 658 references.

The only paper in the present volume not dealing with insecticides is "Principles of Aquatic Plant Control," by T. F. Hall. It covers the harmful effects caused by some aquatic plants the species involved, their nature and its effect on methods of control and concludes with suggested "guidelines" for those faced with aquatic weed problems.